The great capricorn and …

… oaks as promoters for biodiversity

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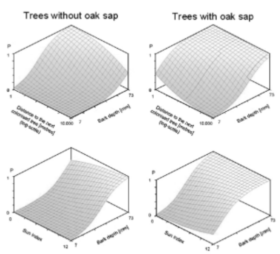

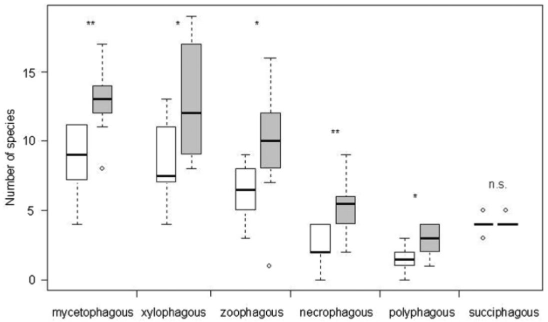

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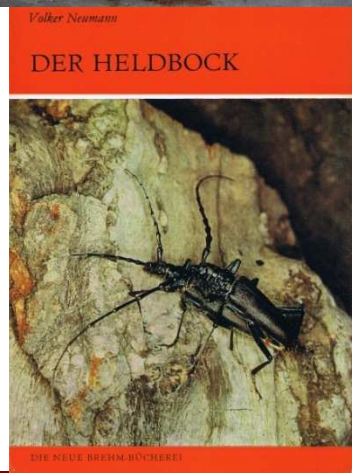
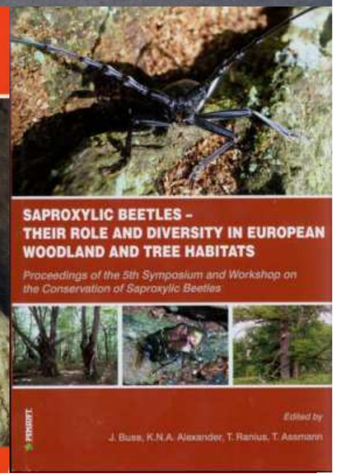
The great capricorn ...

… *Cerambyx cerdo*

- … is a protected saproxylic species (European Habitats' Directive Natura 2000, Appendices II and IV),
- … a charismatic, large insect with sympathy in the public, and
- … shows a strong decline in both number of populations and population sizes:
  - ➢ North-Rhine Westphalia: extinct; Schleswig-Holstein: 1 colonised tree; Lower Saxony: 2 populations





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Overview

- To stop the decline we need information about its habitat requirements.
  - Habitat distribution model
- Do other (endangered) species profit from *C. cerdo*'s habitat?
  - Mark-recapture experiments with ground beetles
  - *Cerambyx cerdo* as a habitat engineer
- Open questions

Jörn Buse

Britta Eggers

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Habitat distribution model

- Presence/absence data
  - 10 predictor variables (e.g. canopy vitability; understory vegetation; position in landscape: solitary, woodland edge, avenues; distance to next colonised tree; sun index; bark depth)
  - 267 oaks ("Gartower Eichenallee", Lower Saxony)
  - 144 oaks (Floodplain area of Elbe river, Saxony-Anhalt)

Buse et al. 2007. Biological Conservation 137:372-381.

Table 1 – Predictor variables measured from each of the oak trees

	Classes	df	Number of cases in presences		Number of cases in absences	
Categorical predictor variables						
Canopy vitality	0 = mostly dead; 1 = partly dead; 2 = vital	2	0 = 14; 1 = 39; 2 = 10		0 = 3 ; 1 = 16 ; 2 = 135	
Trunk vitality	0 = dead parts without bark; 1 = entire bark vital	1	0 = 19; 1 = 44		0 = 7; 1 = 147	
Oak sap	0 = no sap locations; 1 = sap location (s)	1	0 = 30; 1 = 33		0 = 137; 1 = 17	
Understorey vegetation	0 = half trunk length and higher; 1 = lower vegetation	1	0 = 12; 1 = 51		0 = 27; 1 = 127	
Position in landscape	0 = solitary; 1 = woodland edge; 2 = patchy site; 3 = woodland; 4 = avenue	4	0 = 9; 1 = 7; 2 = 27; 3 = 1; 4 = 19		0 = 14; 1 = 12; 2 = 48; 3 = 25; 4 = 55	
	Units		Mean of presences	SD	Mean of absences	SD
Continuous predictor variables						
Trunk diameter (DBH[a])	Measured at breast height in metre	1	1.22	0.36	0.96	0.31
Distance uncolonised	in $[\log_{10} m + 1]$	1	1.02	0.37	0.87	0.29
Distance colonised	in $[\log_{10} m + 1]$	1	1.32	0.51	1.58	0.81
Sun index	[0 = heavily shaded, no direct sun] to [12 = sun from all directions]	1	8.05	3.58	5.79	3.82
Bark depth	Mean of three independent measures in mm	1	32.03	12.01	24.08	8.52

a Diameter at breast height.

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Habitat distribution model

- Presence/absence data
  - Maximum bivariate correlation between predictors is low.
    (r_s=0.384, Spearman rank correlation).
  - Logistic regression with backwards, stepwise variable selection.

Buse et al. 2007. Biological Conservation 137:372-381

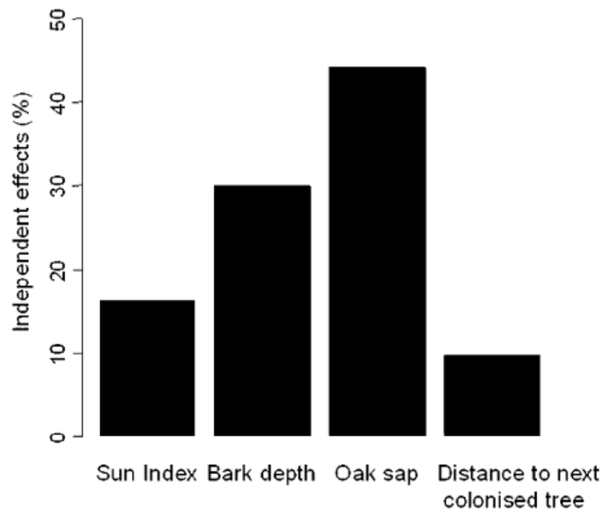

Fig. 2 – Contribution of the individual predictors to the final model response (independent effects calculated by hierarchical partitioning with respect to the log likelihood as goodness-of-fit criterion).

Table 2 – Parameter estimates of the final logistic regression model (residual deviance = 166.55 on 211 degrees of freedom, null deviance = 258.97 on 215 degrees of freedom)

	Variable	Regression coefficient	SE	*p*
β_1	Oak sap	2.636	0.457	<0.0001
β_2	Distance to next colonised tree	−1.081	0.357	0.0025
β_3	Sun index	0.211	0.058	0.0003
β_4	Bark depth	0.102	0.022	<0.0001
β_0	Intercept	−4.491	0.921	<0.0001

Corresponding response surfaces are shown in Fig. 1.

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Habitat distribution model

- Validation of the model (Lower Saxony →Saxony-Anhalt)
  - The final model results in slightly better performance within the test data as the training data.
  - The spatial validation reveals the general transferability of our model.

Buse et al. 2007. Biological Conservation 137:372-381

Table 5 – Performance of the final model and results for the spatial validation on the test dataset

Parameter	Training data (n = 216)	Test data (n = 144)
AUC with 95% CI	0.87 [0.82–0.92]	0.87 [0.83–0.93]
Sensitivity	0.79	0.80
Specificity	0.78	0.82
Correct classification rate	0.78	0.81
Kappa	0.51	0.61

AUC (Area Under Curve) is provided as a threshold independent criterion. Threshold dependent criteria are given with respect to P_{fair} which is the classification threshold where the performance for presences (sensitivity) and absences (specificity) is nearly balanced (see also Table 4).

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Habitat distribution model

Buse et al. 2007. Biological Conservation 137:372-381

- The realised niche:
  - Surprisingly the sun exposition is of subordinate but significant importance.
  - Females prefer protected deep splits in the bark for oviposition
    Döhring 1955. Z angew Zool 42:251-373
  - Food resource for *C. cerdo*; sap spots are doors for disease infections transmitted by sap visiting insects
    Ambourn et al. 2005. Plant Disease 89:1067-1076
  - Metapopulation dynamics?
  - Alternative model: trunk diameter (positive correlation of (endangered) saproxylic species with trunk diameter)

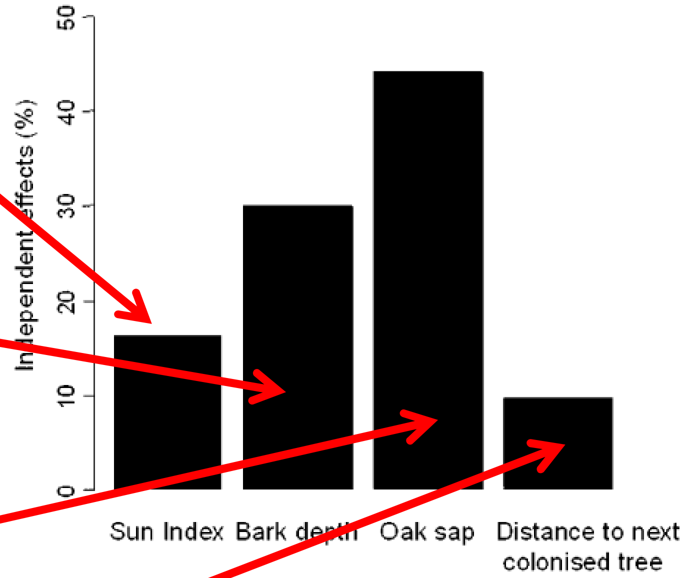


Fig. 2 – Contribution of the individual predictors to the final model response (independent effects calculated by hierarchical partitioning with respect to the log likelihood as goodness-of-fit criterion).

The ideal habitat?

- Semi-open habitats with (old) oaks showing
  - sap spots,
  - deep bark splits (old oaks with big trunk diameter), and
  - short distances to the next colonized trees.

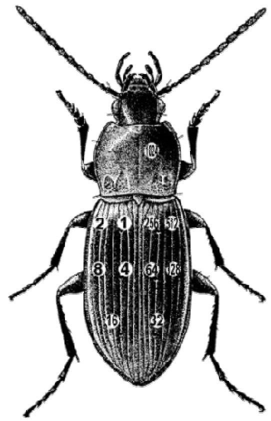
Buse et al. 2007. Biological Conservation 137: 372-381.

Semi-open habitats

- Semi-open habitats provide specific requirements for stenotopic species and they can act as connecting structures.
- Classical habitat corridors (e.g. woodlands, hedgerows or heathlands) fragment the surrounding habitats!
  - A dilemma in conservation biology: connecting landscape structures fragment other types of habitats, at least for stenotopic species!
- Can stenotopic species of both woodland and open habitat (heathland) cross simultanuously semi-open habitats?


10/25

Semi-open habitat concept



- Mark-recapture experiment, open system, 143 pitfall traps
- Heathland and woodland species (*Poecilus lepidus*, *Carabus auronitens*, *Abax parallelepipedus*)
- Species of both groups are able to cross the semi-open corridor!

Eggers et al. 2010. Conservation Biology 24:256-266.

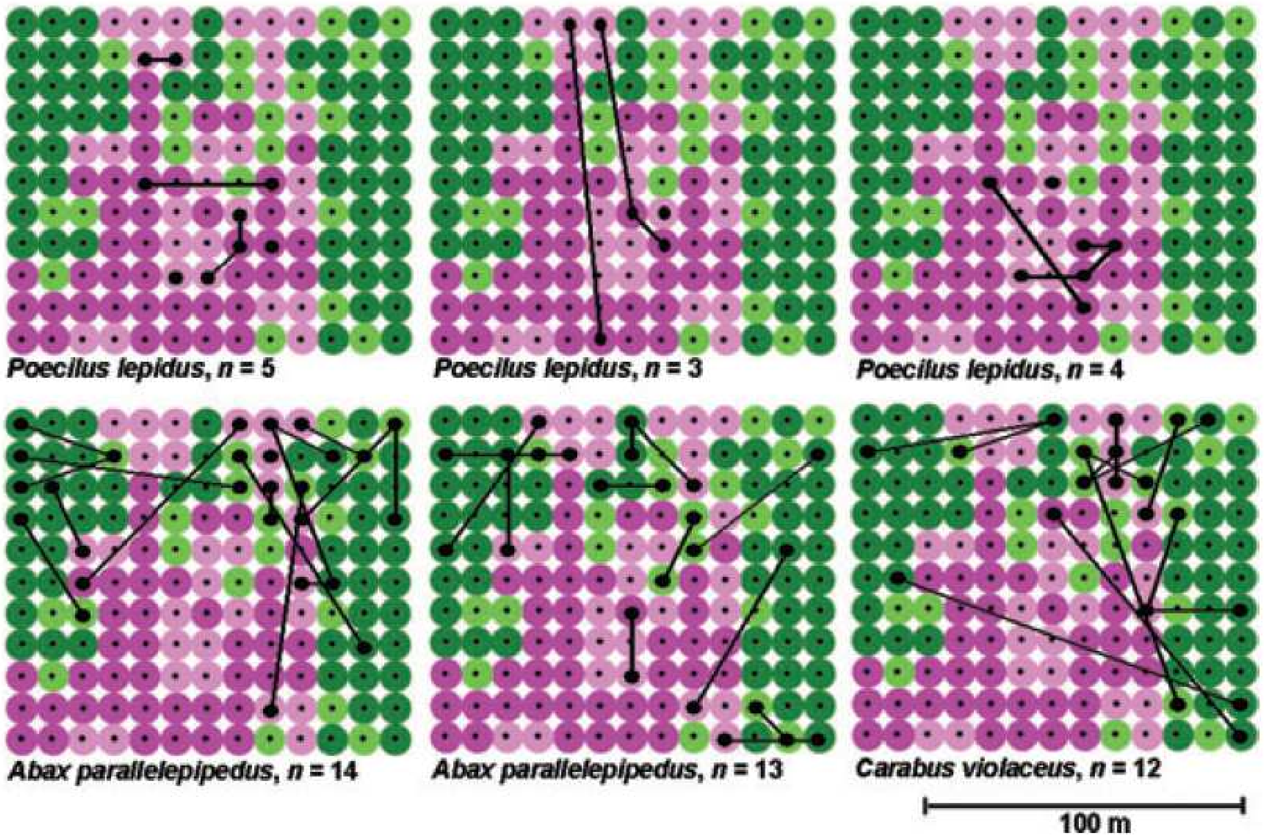


Figure 2. Routes (linear distances) of different, recaptured, individual specimens of P. lepidus, A. parallelepipedus, *and* C. violaceus *in the semi-open habitat (*n*, number of selected specimens in the respective part of the figure; woodland, dark green; semi-open habitat 2, light green; semi-open habitat 1, light purple; heathland, purple; small dots, installed traps; large dots connected by solid lines, recaptured specimens). We defined the habitat by the vegetation in a 5-m circumference around every trap.*

Semi-open habitat concept

- We found stenotopic species of both ecological groups in the same pitfall trap and we are able to detect a lot of crossings for both stenotopic woodland and heathland species.
- Semi-open habitats can not only support endangered saproxylic species but can help to cut the Gordian knot of fragmentation-corridor dilemma!

  Eggers et al. 2010. Conservation Biology 24:256-266.

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Cerambyx cerdo as an ecosystem engineer?

- Ecosystem engineering:
  - nontrophic interactions of an organism that alters the physical state of its environment and affects other species.
- Conservation biology:
  - functional role of some species is of interest because persistence of them may be necessary for maintaining an entire assemblage with many (endangered) species.

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Cerambyx cerdo as an ecosystem engineer?

- "Gartower Eichenallee"
  - 10 colonized and 10 uncolonized trees (randomly chosen from the 216 oaks studied for the habitat suitability model)
  - 7,225 individuals
  - 181 species
  - 41 families

Buse et al. 2008. Conservation Biology 22:329-337.

Cerambyx cerdo as an ecosystem engineer?

➢ Number of saproxylic beetle species captured on trees that were colonized (shaded) and uncolonized by *C. cerdo* and that are recorded in the national Red List of Germany.

Buse et al. 2008. Conservation Biology 22:329-337.

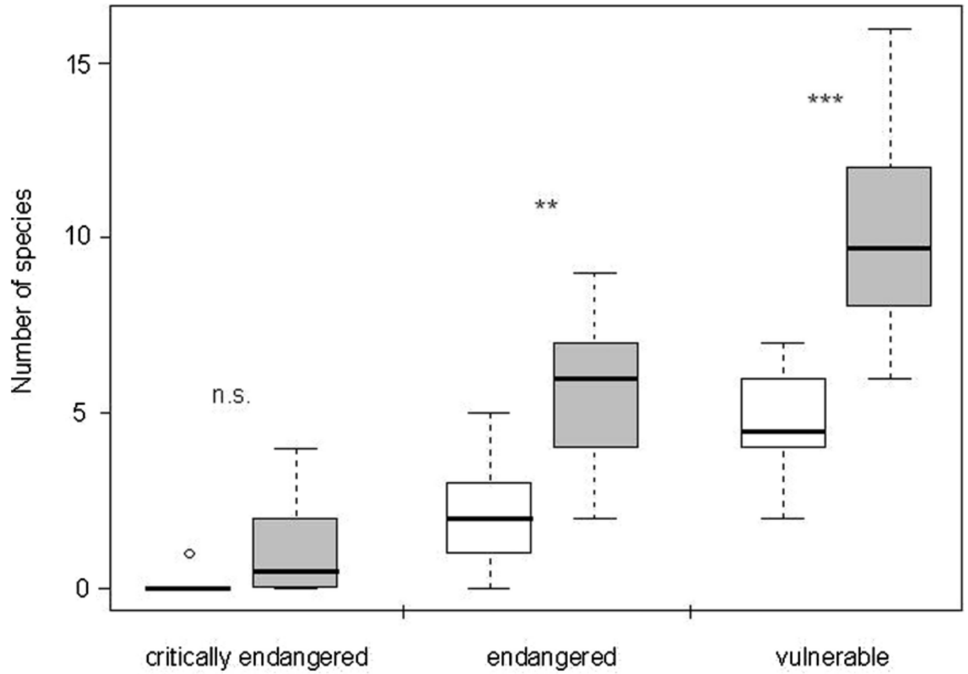

Figure 2. Number of saproxylic beetle species captured on trees that were colonized and uncolonized by C. cerdo *that are recorded in the national Red List of Germany and classified according to the World Conservation Union criteria as critically endangered, endangered, or vulnerable. Shaded bars indicate colonized trees* (n = 10)*, and unshaded bars represent uncolonized trees* (n = 10)*. The horizontal lines show the median, 25% and 75% quartiles, and the dashed lines indicate the range of the data. Differences were tested with the Wilcoxon rank-sum test: critically endangered,* $p = 0.118$*; endangered,* $p = 0.003$*; vulnerable,* $p = 0.001$ *(****$p < 0.001$*; ***$p < 0.01$*; n.s. = not significant).*

Cerambyx cerdo as an ecosystem engineer?

- Number of saproxylic beetle species per feeding guild found on oaks colonized (shaded) and uncolonized by *C. cerdo*.
- 5 of 6 feeding guilds exhibit more species on colonised oaks.

Buse et al. 2008. Conservation Biology 22:329-337.

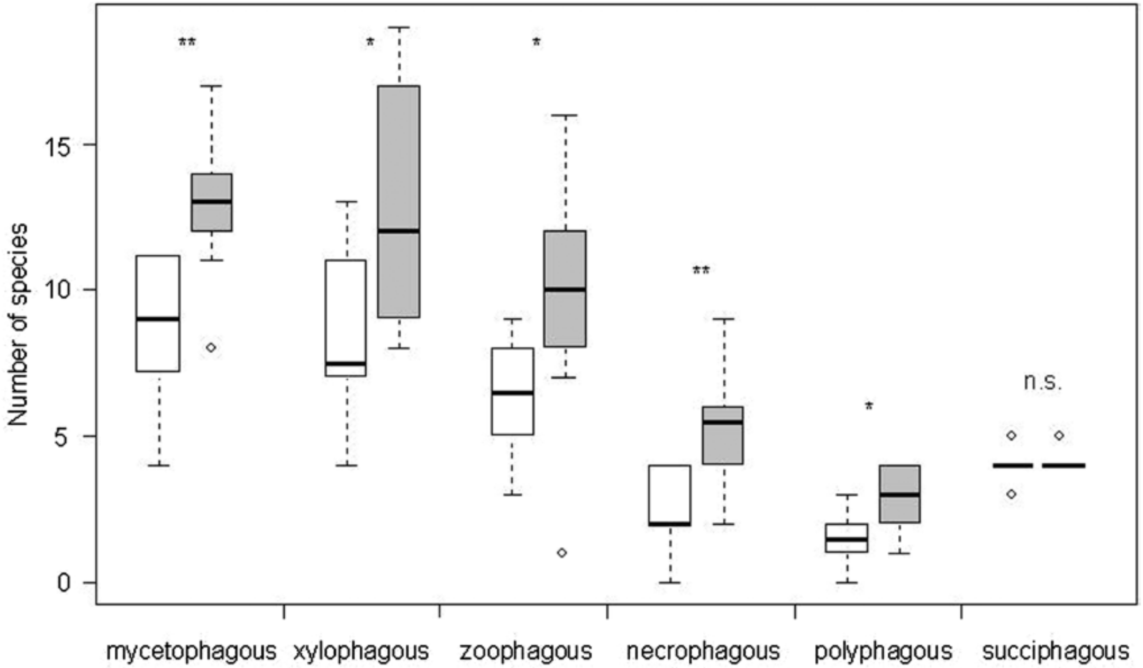

*Figure 3. Number of saproxylic beetle species per feeding guild found on oaks colonized (shaded, n = 10) and uncolonized (unshaded, n = 10) by C. cerdo. The horizontal lines show the median, 25% and 75% quartiles, and the dashed lines indicate the range of the data. Differences were tested with the Wilcoxon rank-sum test: mycetophagous, p = 0.001; necrophagous, p = 0.003; polyphagous, p = 0.011; succiphagous (feeding on sap streams), p = 0.357; xylophagous, p = 0.012; zoophagous, p = 0.015 (**p < 0.01; *p < 0.05; n.s. = not significant).*

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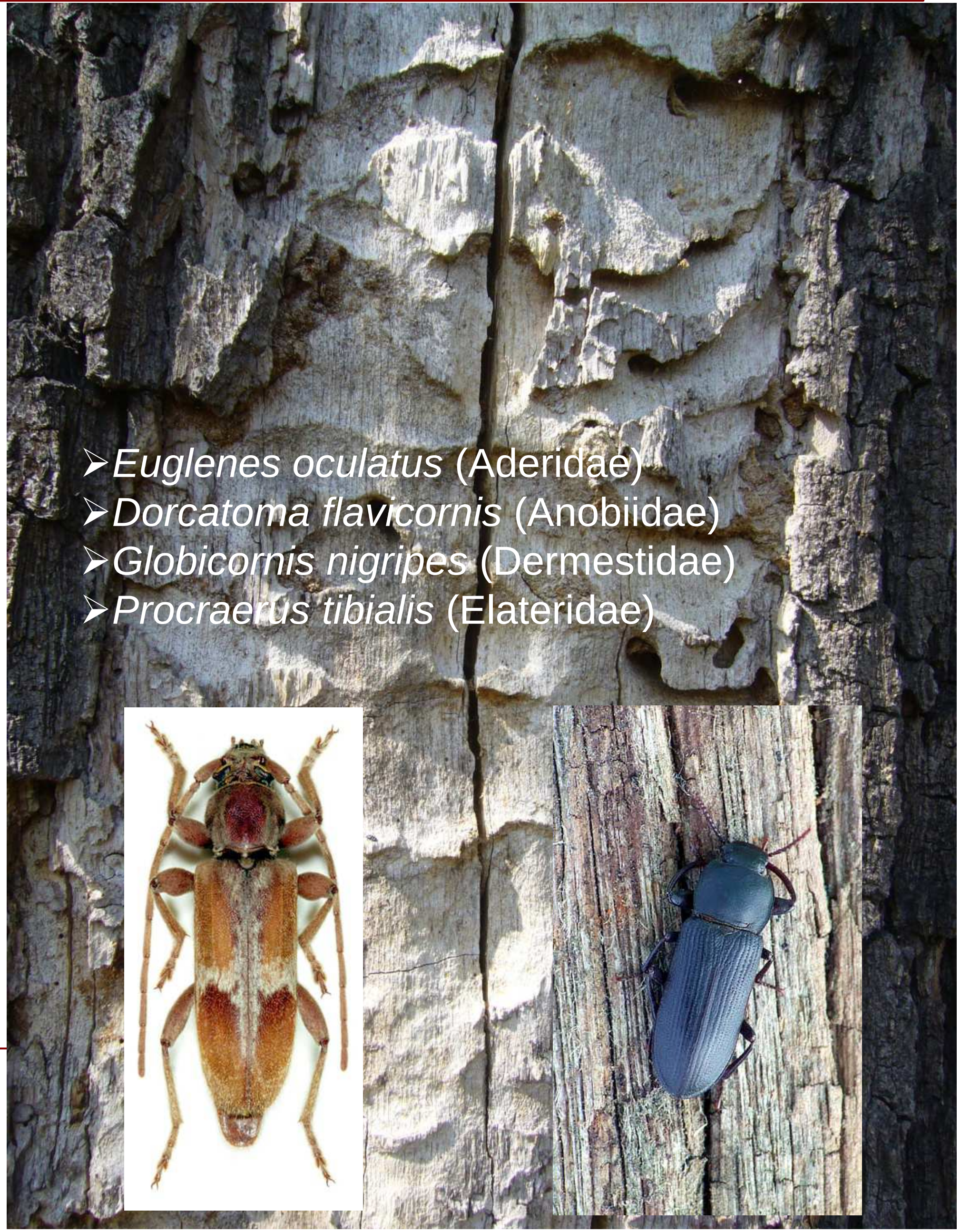
Cerambyx cerdo as an ecosystem engineer?

- Larvae and beetles create a large system of galleries:
  - emergence holes and places where underbark feeding occurred
  - larval galleries inside the trunk (*C. cerdo* is the only Central European beetle able to explore the inner parts of living old oak trees)

    Buse et al. 2008. Conservation Biology 22:329-337.

Cerambyx cerdo as an ecosystem engineer?

- 33 species (31 listed in Red Lists) were exclusively recorded from colonized oaks
  - 4 saproxylic beetle species were strongly ($p<0.01$, Fisher's exact tests) associated with colonized oaks:



- *Tenebrio opaca*
- *Trichoferus pallidus*

Cerambyx cerdo as an ecosystem engineer?

- At least 9 of the exclusive species recorded from colonised
  oaks are primarily hunters on barkless parts of the trunk, e.g.
  - *Colydium filiforme* (Colydiidae)
  - *Dermestoides sanguinicollis* (Cleridae)
  - *Corticeus* spp. (Tenebrionidae).

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Cerambyx cerdo as an ecosystem engineer?

- Other predatory species recorded exclusively on colonized oaks:
  - *Ampedus cardinalis*
  - *Brachygonus megerlei* (Elateridae)

Cerambyx cerdo as an ecosystem engineer?

- We suppose that the feeding habitats of *Cerambyx cerdo* (esp. the larval galleries and emergence holes) create numerous microhabitats necessary for the existence of numerous other insects (incl. many endangered species)
- Ecosystem Engineer
  - scientifically correct proof: experiment
  - ethic problem

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Cerambyx cerdo and Natura 2000

- In the context of insect species conservation the EU habitats' directive has been criticised by numerous authors.
  - Cardoso 2011. Insect Conservation and Diversity doi: 10.1111/j.1752-4598.2011.00140.x
- Listing *C. cerdo* as a species which is supposed to be an important habitat engineer fits well to the overall target of the EU's Directive:
  - Protection of biodiversity!

Insect Conservation and Diversity

Insect Conservation and Diversity (2011) doi: 10.1111/j.1752-4598.2011.00140.x

POLICY

Habitats Directive species lists: urgent need of revision

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Open questions

- Relationship between *C. cerdo* and fungi?
  - *Biscogniauxia mediterranum* in *Quercus suber* stands in Spanish Dehesas

    Martin et al. 2005. Forest Ecology and Management 216: 166-174.
- Sensitivity against pecticids (e.g., dimilin)
- Age structure of oak stands
- Environmental and sustainability education

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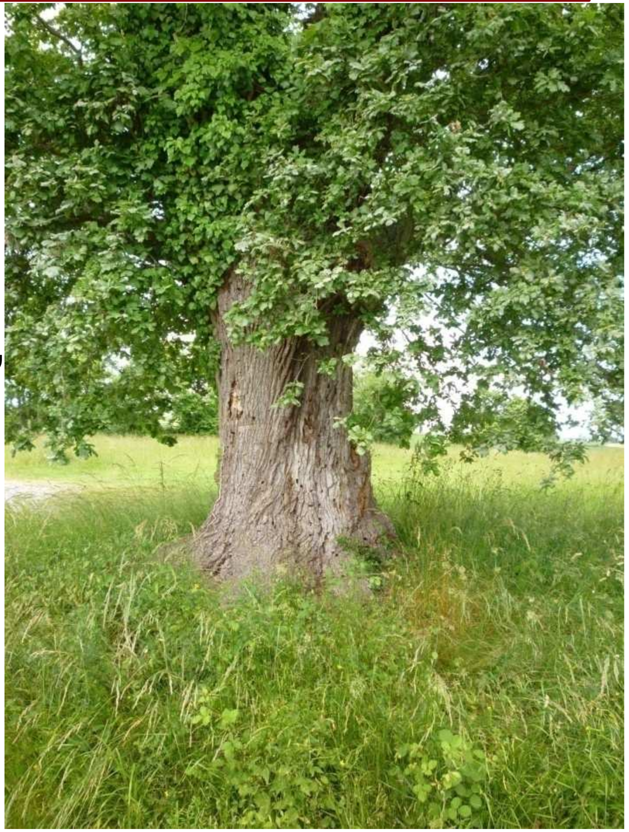
Summing up ...



- *Cerambyx cerdo* prefers oaks with
  - sap spots,
  - deep splits in the bark (old oaks),
  - short distances to the next colonised tree,

  in an open or semi-open habitat.
- Other endangered species can profit from this type of habitat (e.g. woodland and heathland ground beetle species).
- *Cerambyx cerdo* is supposed to be a habitat engineer necessary for maintaining an entire assemblage with many (endangered) saproxylic species associated with oaks.

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Thank you very much for your attention!

Was sind historisch alte Wälder?

- Hasbruch: Eichen mit einem Alter von über 1000 Jahren
  - Amalieneiche (~1980, historische Aufnahme)
  - Friederikeneiche (download)

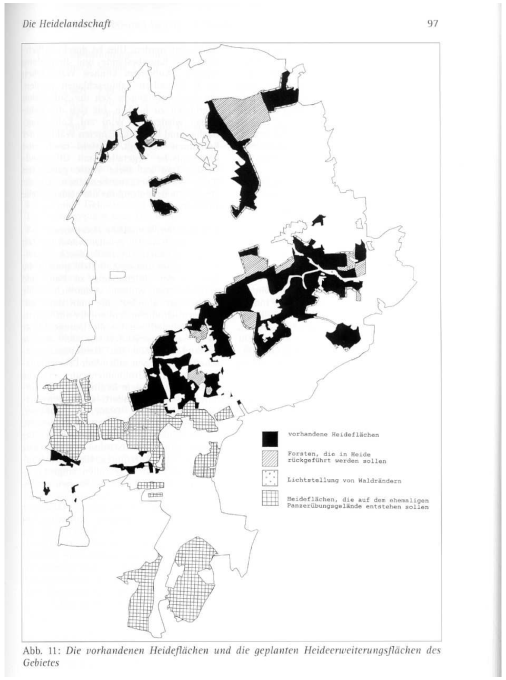
Die Heidelandschaft 97

Abb. 11: *Die vorhandenen Heideflächen und die geplanten Heideerweiterungsflächen des Gebietes*

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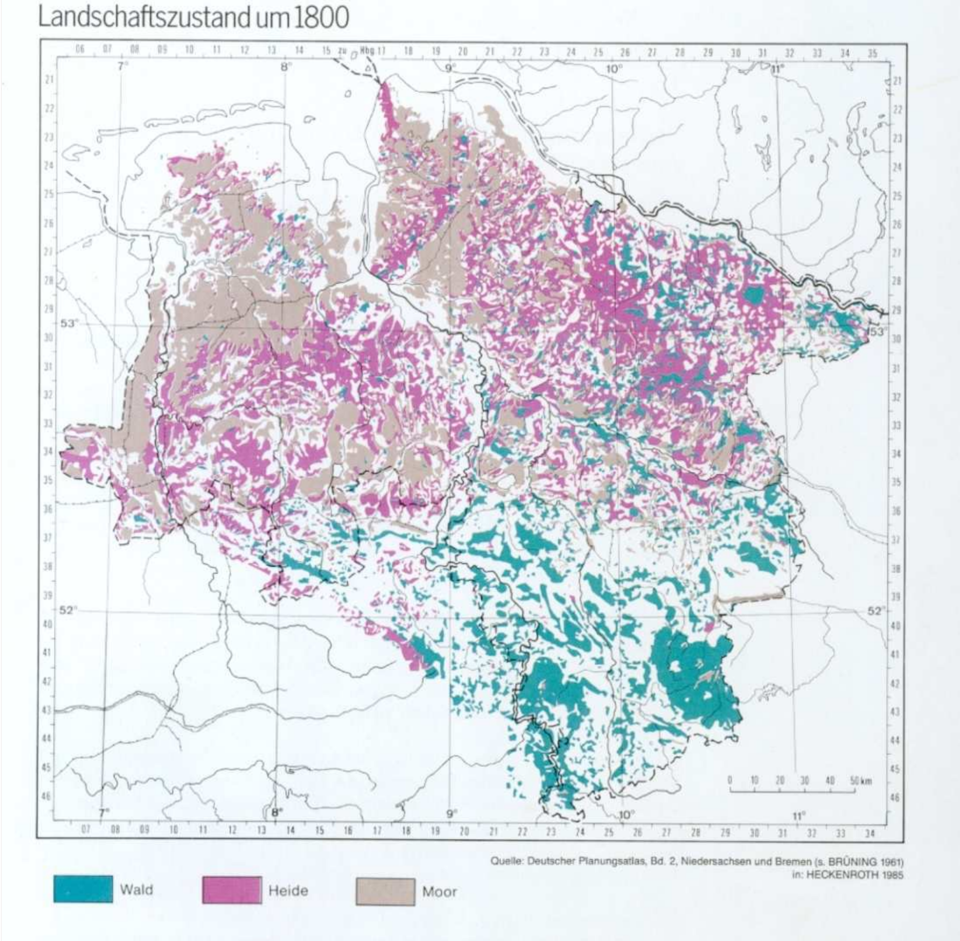
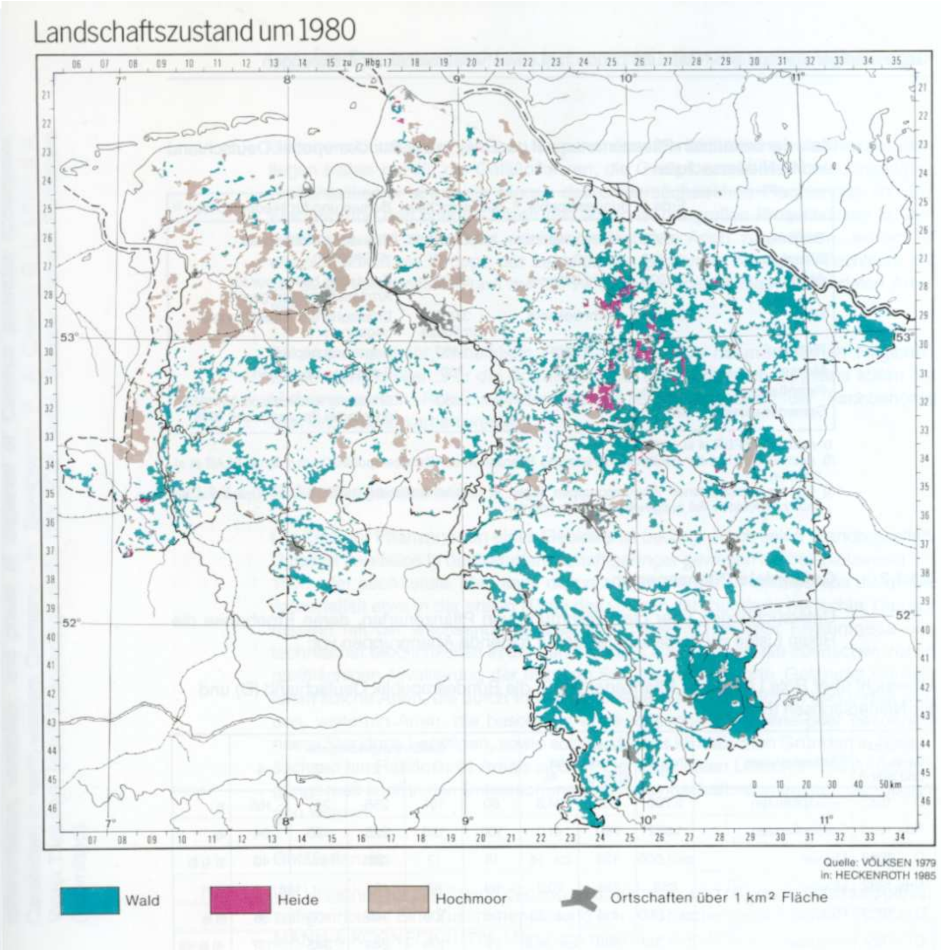
Further information





Vielen Dank ...